

Foreword

Mars has long beckoned to humankind from its travels high in the night sky. The ancients assumed this rust-red wanderer was the god of war and christened it with the name we still use today.

Early explorers armed with newly invented telescopes discovered that this planet exhibited seasonal changes in color, was subjected to dust storms that encircled the globe, and may have even had channels that crisscrossed its surface.

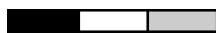
Recent explorers, using robotic surrogates to extend their reach, have discovered that Mars is even more complex and fascinating—a planet peppered with craters, cut by canyons deep enough to swallow the Earth's Grand Canyon, and shouldering the largest known volcano in the solar system. They found intriguing evidence that water played an important role on Mars with channels that bear a striking resemblance to stream beds and clouds of crystalline ice that still traverse its red sky. But they also found that Mars was cold and dry, and believed to be devoid of life.

Now present day explorers have announced that pieces of Mars have arrived on Earth as meteorites, and that these bits of the red planet contain evidence pointing to the possible existence of life early in Mars history. This has resulted in renewed public

interest in this fellow traveler of the solar system, adding impetus for exploration.

Over the past several years studies have been conducted on various approaches to exploring Earth's sister planet Mars. Much has been learned, and each study brings us closer to realizing the goal of sending humans to conduct science on the Red Planet and explore its mysteries. The approach described in this publication represents a culmination of these efforts but should not be considered the final solution. It is our intent that this document serve as a reference from which we can continuously compare and contrast other new innovative approaches to achieve our long-term goal. A key element of future improvements to this document will be the incorporation of an integrated robotic/human exploration strategy currently under development.

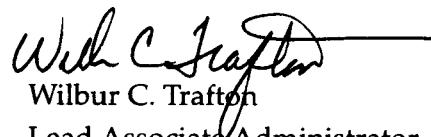
We will continue to develop alternative approaches, technologies, precursor missions, and flight demonstrations that collectively move us forward. Inputs have been, and will always be, encouraged from all sources—NASA centers, industry, research organizations, entrepreneurs, government agencies, international partners, and the public at large—which will improve our understanding and current planning. We plan to use the results of these assessments to shape our investments in technology, and to



look for high leverage, innovative, breakthrough approaches to the most cost effective exploration. These data will also help us understand the required infrastructure, as well as provide important insights into how we can use the International Space Station to validate key assumptions and technologies.

To achieve our goal, we must fundamentally change the way in which we explore with both humans and robots. We

must search for alternatives to substantially reduce the cost of exploration, while increasing the inherent value to humankind. This Reference Mission provides a viable starting point for NASA's continuing efforts to develop the technologies and systems, as well as the international partnerships, needed for the grand adventure of sending humans to explore another planet in our solar system—one that may have once, and may yet again, harbor life.



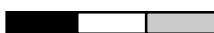
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Acknowledgments

Sending people to Mars has been a long-held dream of humankind, and many have approached the task of turning the dream into reality. This document is another chapter in the ongoing process of melding new and existing technologies, practical operations, fiscal reality, and common sense into a feasible and viable human mission to Mars. However, this is not the last chapter in the process, but marks a snapshot in time that

will be added to and improved upon by others in the future. This report has benefited from the contributions and advice of many individuals from the government and private sectors. The individuals listed on the following page assisted in preparing the concepts described in this report and in compiling the words, images, and data used for that description.

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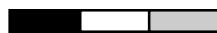
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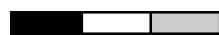
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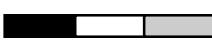


There is a set of supplemental technical reports which provide greater depth into many of the design features of the Mars Reference Mission than is given in section 3 of this document. Had those papers been included as appendices, the size of this document would have greatly expanded. Consequently, we decided to make those supplemental materials available through the world wide web. We intend to post new materials as to the web as they are produced and hope to maintain a site with the latest information which describes key technologies and design features of a human mission to Mars.

The site for the Mars Reference Mission is

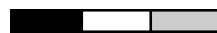
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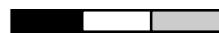


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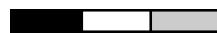
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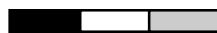


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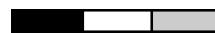
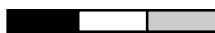


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Acronyms

AMCM	Advanced Missions Cost Model	MTV	Mars transfer vehicle
COSPAR	Committee on Space Research	NASA	National Aeronautics and Space Administration
CPAF	cost plus award fee	ND	NERVA derived
CPFF	cost plus fixed fee	NDR	NERVA derivative reactor
DIPS	Dynamic Isotope Power System	NERVA	nuclear engine for rocket vehicle application
ECCV	Earth crew capture vehicle	NTR	nuclear thermal rocket
ERV	Earth return vehicle	PI	principal investigator
ETO	Earth-to-orbit	PVA	photovoltaic array
EVA	extravehicular activity	RFC	regenerative fuel cell
GCR	galactic cosmic radiation	RTG	radioisotope thermoelectric generator
HMF	health maintenance facility	SPE	solar proton event
HLLV	heavy-lift launch vehicle	SSME	Space Shuttle Main Engine
IAA	International Academy of Astronautics	STS	Space Transportation System
IMLEO	initial mass to low Earth orbit	TEI	trans-Earth injection
ISRU	in-situ resource utilization	TCS	Thermal Control System
LEO	low Earth orbit	TMI	trans-Mars injection
LMO	low Mars orbit	TROVs	telerobotic rovers
LOX	liquid oxygen		
LSS	life support system		
MAV	Mars-ascent vehicle		
MGS	Mars Global Surveyor		
MOI	Mars Orbit Insertion		

